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**A DISEQUILIBRIUM MODEL OF REGIONAL INVESTMENT**

**by**

**Robert F. Engle**

**Number 121**

**November 1973**

**massachusetts  
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## ABSTRACT

A regional investment equation is developed based upon the marginal rate of return to capital in one location relative to that in another. The relation is argued to be more reasonable for a regional economy where capital can flow freely across regions, than traditional supply and demand of loanable funds analyses. The equation is fitted for Massachusetts manufacturing data disaggregated into four sectors. The equation fits well with a three year distributed lag and indicates long run elasticities between .5 and 2. An accelerator is nowhere significant.

## A DISEQUILIBRIUM MODEL OF REGIONAL INVESTMENT

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The supply of factors of production in a regional economy determines the potential income of the economy. Thus the analysis of the sources and causes of regional investment is of paramount interest to both regional planners and theorists. Recently there have been several econometric investigations of the determinants of regional investment; however, all of these, whether a single equation in a bigger model (1), (3), (6), or an entire investigation of investment,(7), adopt, without discussion, specifications based upon national studies. In this paper we will argue that in a small open economy, a different specification is necessary. A disequilibrium model based on the theory of international capital flows is developed and tested against data for Massachusetts.

### I. The Model

Most national models are based upon a comparison of the cost of capital services and the expected rate of return to these services. Heated controversies revolve around the measurement of these variables and the functional forms of the estimates, but each can be viewed as a special case of the general supply and demand for loanable funds.

For a regional economy, as for a small country with no restrictions to foreign investment, a different approach seems promising. No longer is the cost of borrowing within the region a determinant of investment because the source of funds can be any other region. The total supply of loanable

funds and physical investment will depend on conditions in the national money markets and in the capital goods industries respectively, both of which are presumably exogenous to the region. Total demand is the sum of the individual regional demands, and again, this is primarily exogenous to the region. The allocation of this pool of investment to the different regions depends upon the individual demands; and if regions are close substitutes, as we would expect for impersonal owners of corporate capital, and for open regions, then the allocation should depend upon the differential rates of return among regions.

In equilibrium, in the absence of other factors, the marginal rate of return to investment should be equal in all regions, since, with diminishing returns to capital, any increase in investment will lead to a decrease in the rate of return. If capital flows rapidly from one location to another and especially if old capital can be uprooted and relocated in a new and more profitable region, we might never observe differing profit rates, only the large flows of investment. The resulting equilibrium does have testable characteristics and, although the evidence is not very strong, (2), (8), and (9), it does support the long run equilibrium configuration generated by this model of capital flow. However, if disequilibrium lasts several periods we should observe investment flowing toward regions of higher profit rates.

This type of model has been used extensively in explaining labor migration - see for example Greenwood (8) or Olvey (13). However, because of the substantial non-pecuniary benefits to labor, the theory should be more effective in explaining capital flows than labor flows. Borts and Stein (2) employ basically this model in examining investment behavior, however, their formulation, which attempted only to measure long run behavior, was only partially successful. It differs from the present model in that only wages were considered as determinants of regional investment behavior.

In this paper we will use annual data to estimate regional manufacturing investment functions for Massachusetts under the presumption that equilibrium will not be restored in less than a year. Thus capital flows should be in the direction of the highest profit rates. The basic model is

$$(1) \quad I^M = a_0 + a_1 I^{US} + a_2 r^M / r^*$$

where  $I^M$  and  $I^{US}$  refer to investment in a particular industry in Massachusetts and in the US,  $r^M$  is the marginal rate of return to capital in this industry in Massachusetts, and  $r^*$  is the rate of return elsewhere. We consider  $r^*$  sometimes as the average rate of return in the whole nation, and sometimes as the rate of return in the single most profitable alternative location in the nation. We expect the coefficients to be positive and that a distributed lag on the relative profit rate would shortly go to zero indicating that equilibrium was restored.

## II. Data

The most critical data problem is measurement of the marginal rate of return to capital. If the basic production technology is Cobb-Douglas, and if all regions have access to the same technology, then, the ratio of the average rates of return between two areas will be exactly equal to the ratio of the marginal rates of return. If the elasticity of substitution is constant but not equal to one, the result will still be true if capital-labor ratios, or equivalently wage-rental ratios, are the same. For a CES production function, the ratio of the average to the marginal product of capital is:

$$(2) \quad \text{APP}_K / \text{MPP}_K = 1 + \frac{1-\delta}{\delta} (L/K)^{1-1/\sigma}.$$



If sigma is close to unity or if capital-labor ratios do not diverge greatly between regions, the average product of capital will be proportional to the marginal product.

The difference between value added and the total wage bill is a rough measure of total profits. According to the definition used by the Annual Survey of Manufacturers, this measure is net of transport costs for both inputs and outputs. Thus shipping charges from points of supply and to the marketplace have already been subtracted, and consequently, a firm should be indifferent between locations in which he can sell products with equal value added, as long as his other costs are the same.

The definition is however, gross of some payments for business services, rentals of land and equipment, depreciation and taxes. These costs should be also subtracted before the rate of return to owned capital can be calculated, however, assuming that these costs remain a fixed proportion of output (which would be the case if the elasticity of substitution of the factor was unity) or that this proportion changes similarly in different regions, our measure of the relative profit rate should be highly correlated with the true rate.

To obtain the average rate of return to capital, we must divide total profits by the capital stock. Measures of the capital stock are always quite crude, even at the national level. At the regional level, we must rely on book value benchmarks from 1957 and 1964 from the Census of Manufacturers and use the perpetual inventory method to generate a series which matches both benchmarks.

Average profit rates were calculated for two digit manufacturing industries from 1954 to 1971 for the state of Massachusetts and for the US

as a whole. This data is aggregated to four manufacturing sectors in order to be consistent with the definitions used in the model of the Boston SMSA<sup>1</sup> described in (4) and (5). There are two non-durable and two durable sectors: non-durables 1 is the textile-apparel-leather sector which historically was Boston's major product but which recently has been in a steep decline, and durables 1 is the electronics-machinery-technology sector which has grown dramatically since the fifties but which is now being supplanted by business services as Boston's major product. The balances, which highlight printing and processed foods, and primary and fabricated metal products are, non-durables 2 and durables 2 respectively.<sup>2</sup>

Especially in the case of Boston's declining sector, textiles, and leather, but also for other industries, it can be argued that the alternative location for new investment is a particular region, not the US as a whole. To model this we also constructed annually average profit rates for two states which were potential competitors for each industry. These states were those with the highest profit rates in 57 and 64 among the set: New York Pennsylvania, Illinois, California, Texas, Colorado, Florida and Georgia. In each year the highest was chosen and used as  $r^*$  in equation (1), so it was possible and frequent that the alternative state would change over the sample period.<sup>3</sup>

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1

Much of the data is not available for the SMSA in various years. As Boston is the major industrial center of the state, we felt that the use of Mass. data would indicate the behavior of the SMSA as well.

2

ND1 includes SIC codes 22, 23, 31; ND2 includes 20, 26, 27, 30; D1 includes 35, 36, 37, 38 and D2 includes just 34. Data for the other smaller sectors which are used in the Boston model were not available.

3

When aggregating to the four sector categories, the aggregate was constructed from the best states for each of the industries.

### III. Results

After trying a variety of lag structures for equation (1), the best and simplest appeared to be a three year moving average of lagged relative profit rates. The unconstrained lag weights showed the typical zigzag shape which results from multicollinearity among the lagged values. We present in each case the F statistic for the test that the linear restrictions are appropriate and we can never reject this hypothesis, even at the 25% level for three of the sectors. For the fourth, we do reject at the 5% level but not at the 2.5% level, which indicates that possibly a better lag distribution can be found. The unconstrained form showed a very significant initial effect and a significant two year lag weight but an insignificant one year lag. We invoke a prior belief in smoothness to abandon this shape in favor of the same uniform lag distribution. It is well to notice that this time lag is roughly consistent with that found in national investment studies - see for example Jorgenson (10).

For the three sectors which showed an absolute decline in employment over the two decades, ND1, ND2, and D2, the alternative location for investment appeared to be the state with the highest profit rate. However, for D1, the electrical and non-electrical machinery and instrument sector, the alternative profit rate in the US was a better variable. While this is possibly a result of the limited alternative states considered, it is not surprising theoretically. We might expect that a growing sector would compete with a wide variety of states for its investment, while a declining sector is possibly declining because a particular region has recently developed a comparative advantage in this product. That is, if Massachusetts is to the electronics industry, what the south is to the textile industry, we would fully expect that the

alternative for electronics would be the whole US. Finally, in this sector, alone, a lagged value of US investment proved important.

These equations are presented in Table 1. They are fitted with post-Korean war data from 1956 to 1971. Each equation exhibits Durbin-Watson statistics above 2, indicating potential negative serial correlation, which can be accounted for only by some anomaly of the sampling or reporting procedure of the Survey of Manufacturers. These statistics are however an indication of the great variability of these series. To indicate the variation within these series and the effectiveness of our model in explaining it, the actual and fitted values are plotted in Figures 1 - 4.

These results are quite encouraging for this approach to modeling regional investment. The  $R^2$  are quite high, even for the declining sectors, and all variables are significant, some with very high t values. The fits are quite good with the fitted values picking up a great many of the turning points.

The long run elasticities of investment with respect to relative profit rates are between .5 and 2. The size of these elasticities indicates a substantial effect for policies which alter the relative profit rates such as corporate taxes, wage subsidies, transportation investments and land acquisition services. That is, a decrease in corporate profits tax in one region relative to the rest of the country by one percent, would lead to a similar percentage increase in investment in each of these industries.

#### IV. Tests Against Traditional Models

While it is clear from these results that relative profit rates have an effect on investment, it is quite possible that there are really two types of investment processes involved. There may be some capitalists who



TABLE 1

Estimates of MASSACHUSETTS Investment Equation 1956-1971

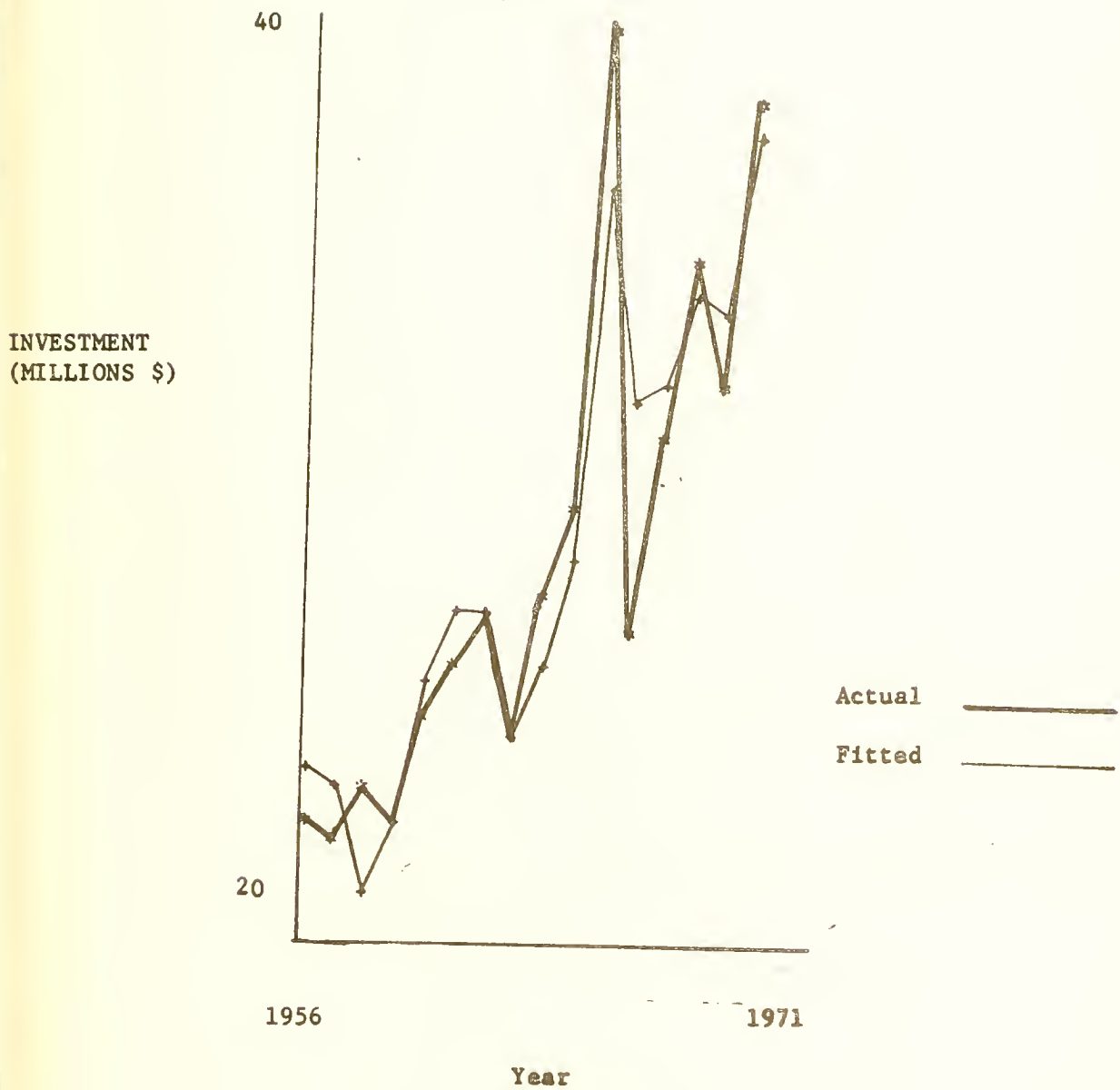
IMND1	=	-3.54 (-.57)	+	24.12 $\overline{\text{RP}}$ (3.01)	+	.017 IUSND1 (10.06)	
R <sup>2</sup>	=	.886,	DW = 2.26,	F <sub>2, 11</sub>	LAG RESTRICTONS = 4.9,	L.R. ELAST = .64	
IMND2	=	-147.6 (-1.89)	+	207.5 $\overline{\text{RP}}$ (2.08)	+	.026 IUSND2 (11.83)	
R <sup>2</sup>	=	.917,	DW = 2.26,	F <sub>2, 11</sub>	LAG RESTRICTIONS = .58,	L.R. ELAST = 1.57	
IMD1	=	-156.6 (-2.60)	+	89.68 $\overline{\text{RPUS}}$ (2.45)	+	.025 IUSD1 (3.86)	+.023 IUSD1(-1) (3.74)
R <sup>2</sup>	=	.956,	DW = 2.65,	F <sub>2, 10</sub>	LAG RESTRICTIONS = .36,	L.R. ELAST = .86	
IMD2	=	-24.98 (-2.74)	+	30.87 $\overline{\text{RP}}$ (3.36)	+	.018 IUSD2 (5.83)	
R <sup>2</sup>	=	.854,	DW = 2.23,	F <sub>2, 11</sub>	LAG RESTRICTIONS = .98,	L.R. ELAST = 1.5	

Notes: RP is the MASS profit rate relative to the best state.

RPUS is the MASS profit rate relative to the US.

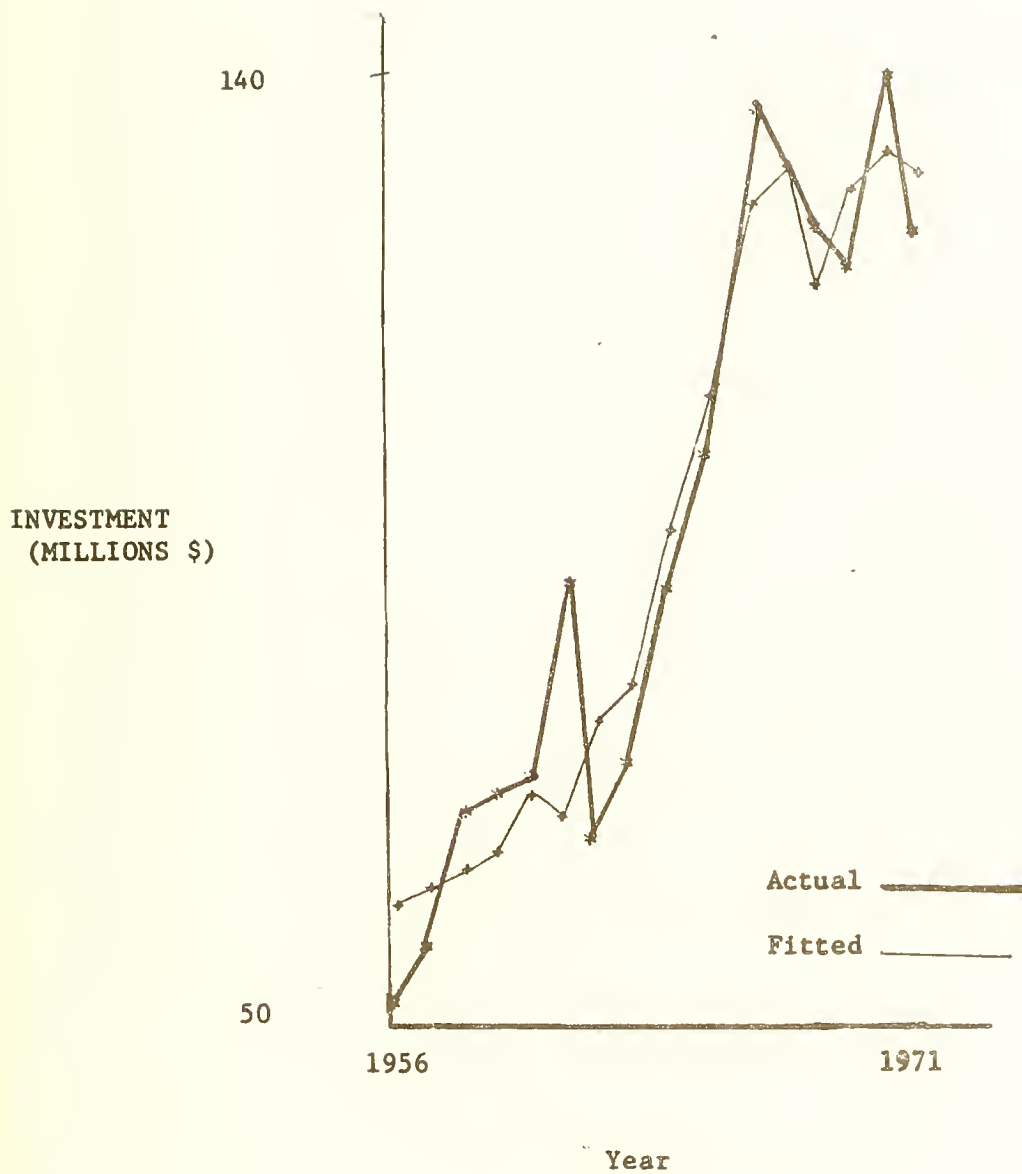
A bar over a variable indicates a three year moving average  
t-statistics are in parentheses.

L.R. ELAST is the long run elasticity and calculated at the mean of  
investment relative to the profit rate.



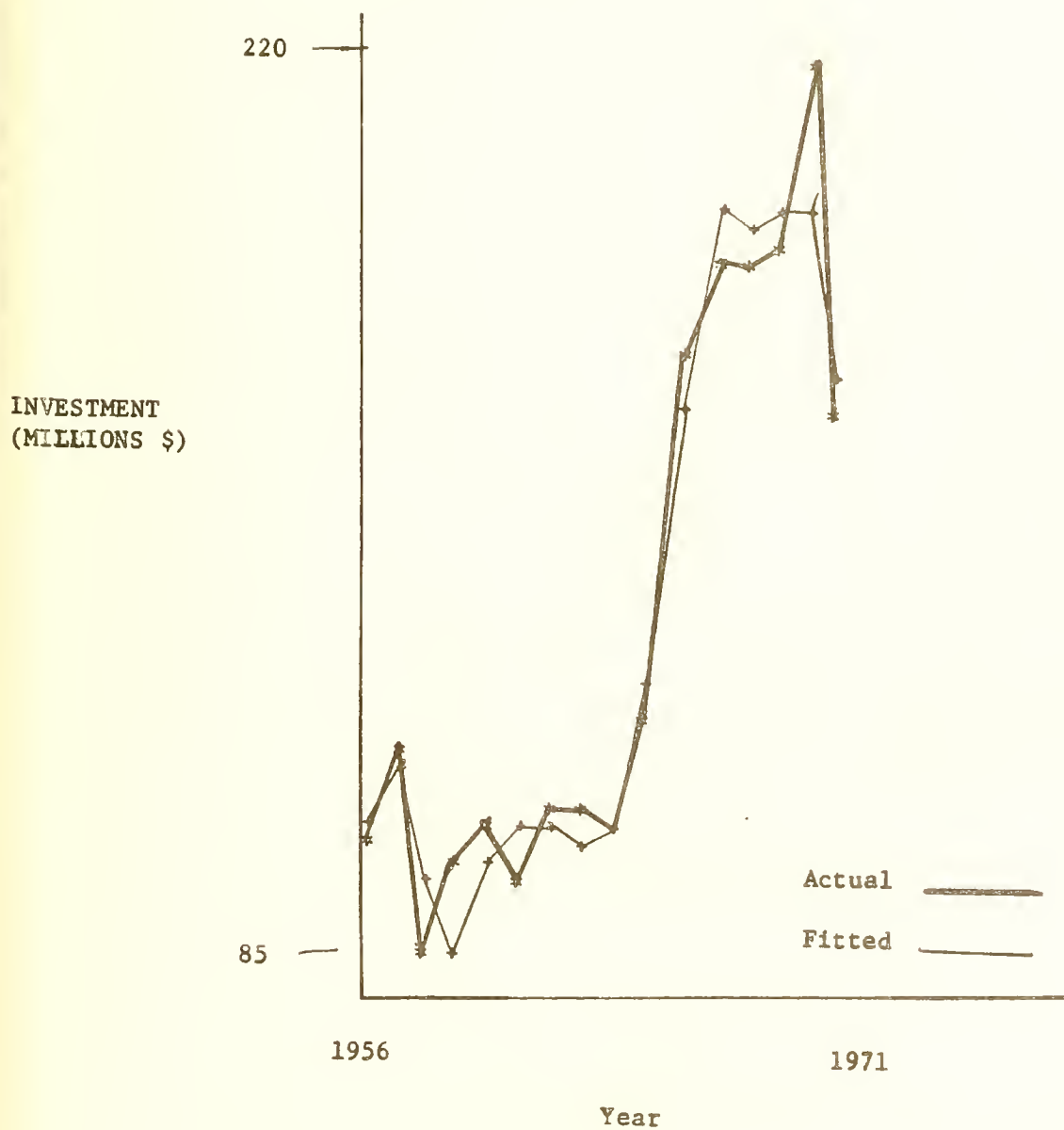
ACTUAL AND FITTED VALUES IN ND1

Figure 1



ACTUAL AND FITTED VALUES IN ND2

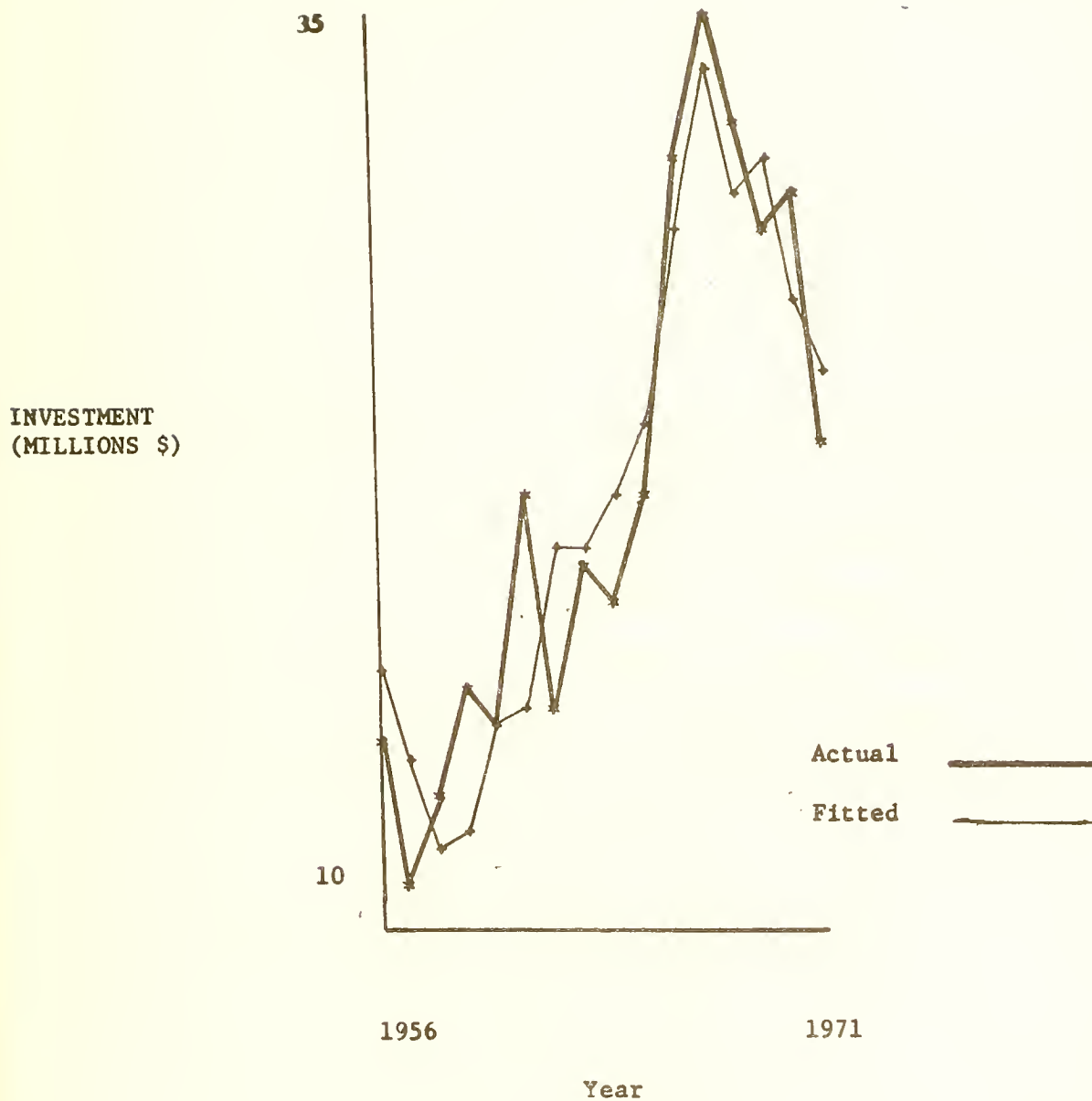
Figure 2



ACTUAL AND FITTED VALUES IN D1

Figure 3





ACTUAL AND FITTED VALUES IN D2

Figure 4

survey the alternative sites for a new investment project and place it in the spot with the highest rate of return. There may be others who are not mobile and who therefore invest or not on the basis of traditional investment theory. These investors would presumably equate the marginal return to new investment with their own cost of funds, not with the rate of return in another location. In so far as the rate of return elsewhere influences the cost of funds here, these may be indistinguishable, however, it seems that the slippages are sufficiently important that we should consider this component of investment separately.

The simple <sup>b</sup> accelerator has been found to be as good an explanatory variable as any in recent comparisons, Bischoff (2). Therefore we introduced a first difference on value added into our equation (1), and reestimated all the equations. The results were dramatic in rejecting this additional variable. The coefficients of the original variables were changed very little and the accelerator was nowhere significant. The values for the accelerator coefficients and their t- statistics are:

Sector	<u>ND1</u>	<u>ND2</u>	<u>D1</u>	<u>D2</u>
Coef	.014	.041	.023	.0024
t-stat	(1.41)	(.57)	(.79)	(.079)

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